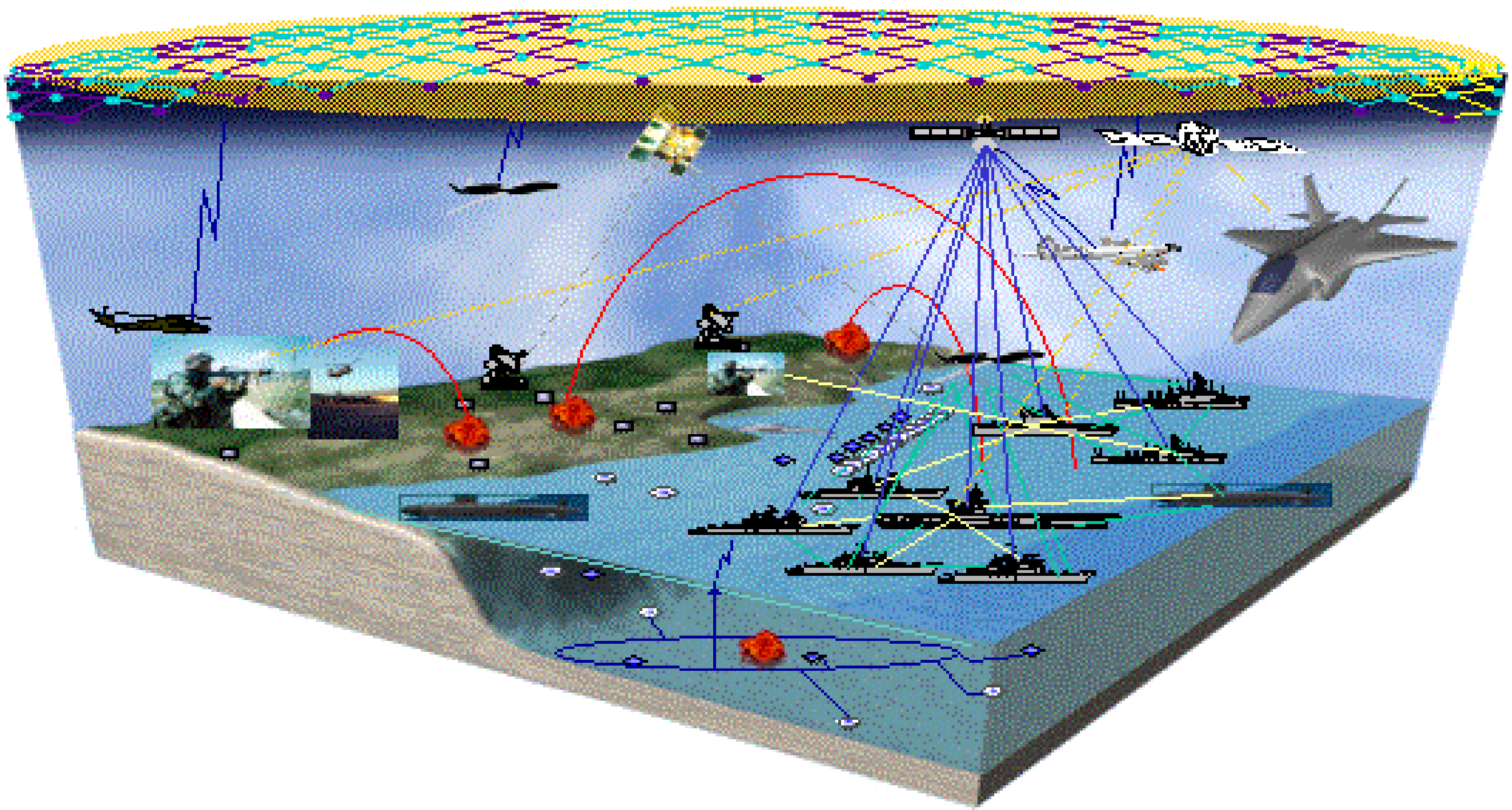
AY 2004 Spring Integrated Project

Maritime Dominance in the Littorals



Wayne E. Meyer Institute of Systems Engineering

Naval Postgraduate School, Monterey, CA

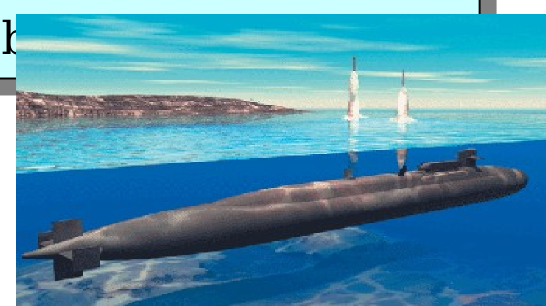
Project Description

- Execute Tasking from Deputy Chief of Naval Operations (CNO) for Warfare Requirements (OPNAV 7)
- Develop a Conceptual System of Systems (SoS) for Maritime Dominance that Enables SEA BASING and SEA STRIKE in the Littorals
  - Generate Alternatives Using Existing Systems, Current Programs of Record, and Future Systems
  - Recommend Cost Effective Conceptual SoS That Minimizes Risk To Allied Personnel While Accomplishing Objectives
- Deliver Results in a Final Briefing and Technical Report

SoS Focus and Constraints

- **SoS Architectural Focus**
  - Combination of both Manned and Unmanned Systems
  - Surface, Subsurface, Air and Space Syste
  - Employment of Forces From All Services

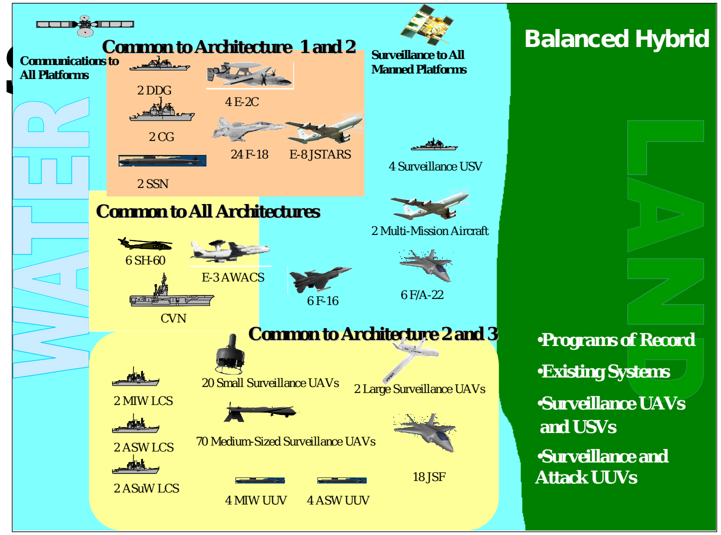
- **Constraints**
  - Scenario Constraints
    - Land Forces Deployed up to 200 nm Inland
    - Striking/Supporting Maritime Forces Deployed up to 200 nm Offshore
  - Timeframe Constraint
    - Concepts of Operations Applicable within 2020 Timeframe
  - Cost Being a Necessary Selection Variab

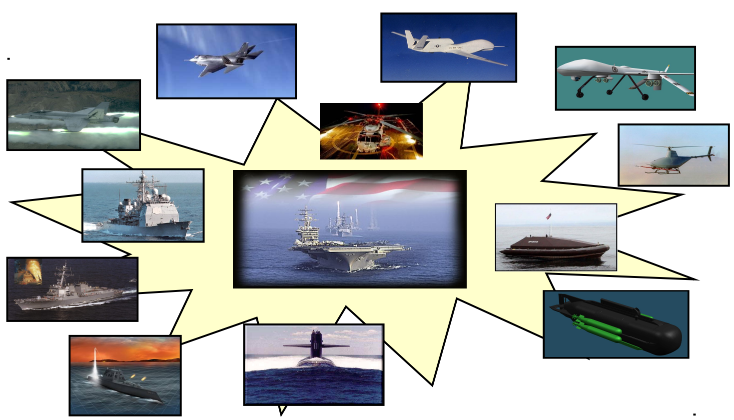


for Maritime Dominance in

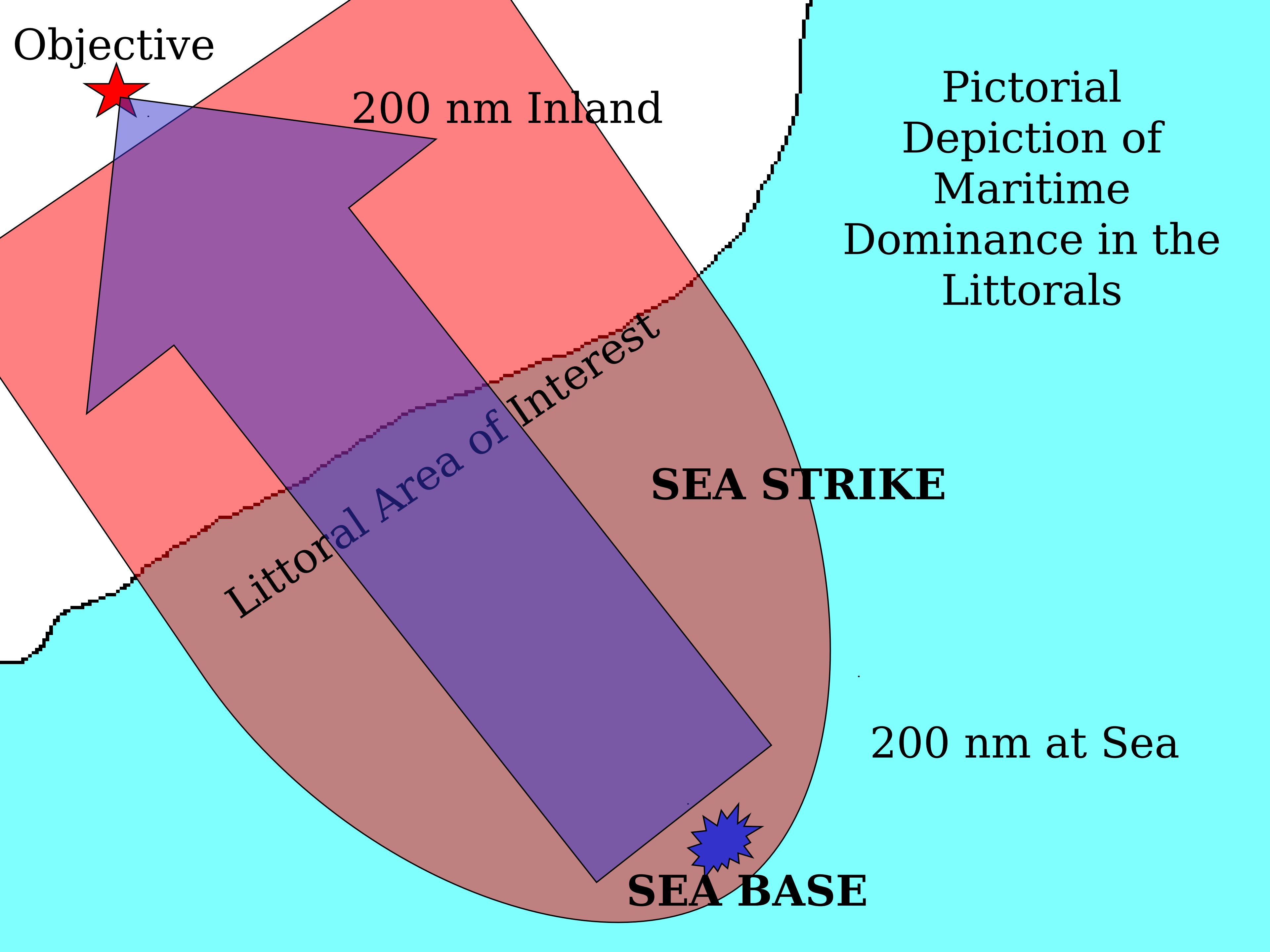
rals

- **•Unmanned Vehicles Complement But Cannot Replace Manned Platforms**
- **•Recommended System of Systems Enabling SEA BASING and SEA STRIKE in 200 nm by 200 nm Littoral Operation Area in 2020 Timeframe**
  - **Consists of Unmanned/Manned Vehicle Ratio of Approximately 1.5 to 1**
  - **Utilizes Distributed Communications with 100nm Physical Platform Distribution**
  - **Employs Decentralized Command & Control Structure**
  - **Is Cost Effective Relative to Other Alternatives**





- **Distributed Communications**
  - Faster Dissemination of Information
  - Minimum Impact on Throughput with Node Failures
- **Decentralized Command and Control**
  - Shorter Reaction Times
  - Less Network Demand
  - Single C2 Node Failure Avoidance
- **100 nm Platform Distribution**
  - Superior Overall Performance



Objective
200 nm Inland
Pictorial Depiction of Maritime Dominance in the Littorals
Littoral Area of Interest
SEA STRIKE
200 nm at Sea
SEA BASE

2004 Integrated Project Interface

NPS Community

Faculty Advisors

Prof. W. Solitario-Overall Project Coord
Dr. T. Huynh-Proj. Mgmt, Sys. Design & Analysis
Dr. R. Cristi-Communications
Dr. D. Kapolka-Sensors
Dr. G. Karunasiri-Sensors
Dr. I. Kaminer-Land Systems
Dr. F. Papoulias-Land Systems
LCDR R. Gottfried-Operations Research
Prof. K. Burke-Information Systems

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Northrop Grumman
Raytheon

Study Direction, SEA5 Technical Inputs Contributing Analysis

Performance Analyses

Technology Resource

SEA5

Integrated Project Lead

LCDR Q. Tran

SEA5 Team

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Initial Study Plan Periodic Updates

Input and Feedbac

Operational Requirements

CNO N7
Fleet Commanders (CAPT Kline, Dr. Olwell)

Technical Requirements

NAVSEA
FNMOC
NCAA
AFCAA

End User Requirements

Community
Air Warfare
Amphibious Warfare
Land Warfare
PYSOPS/INTEL
Special Operations
Subsurface Warfare
Surface Warfare

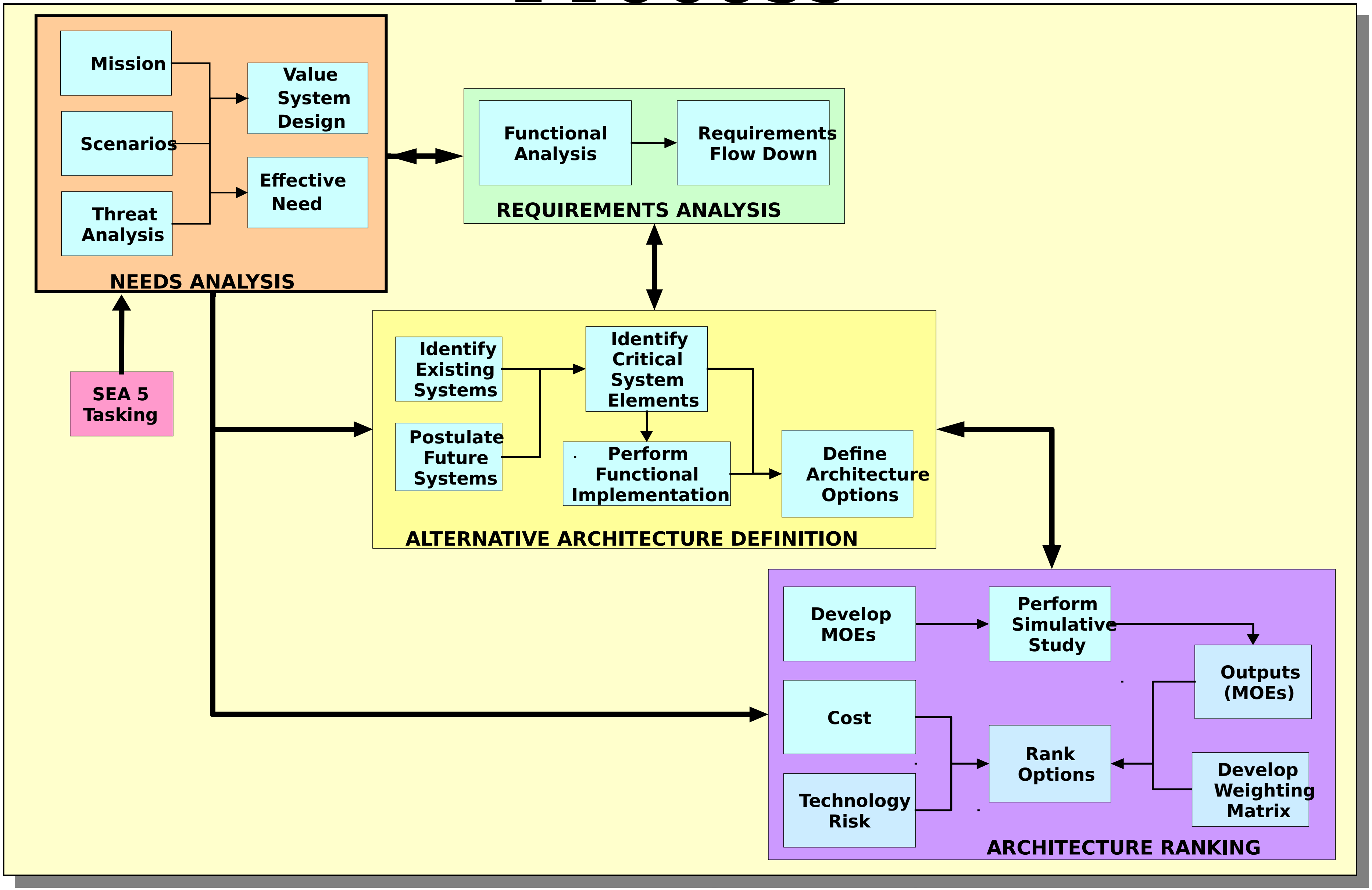
Legend

Primary Coordination
Internal
External
Stakeholders

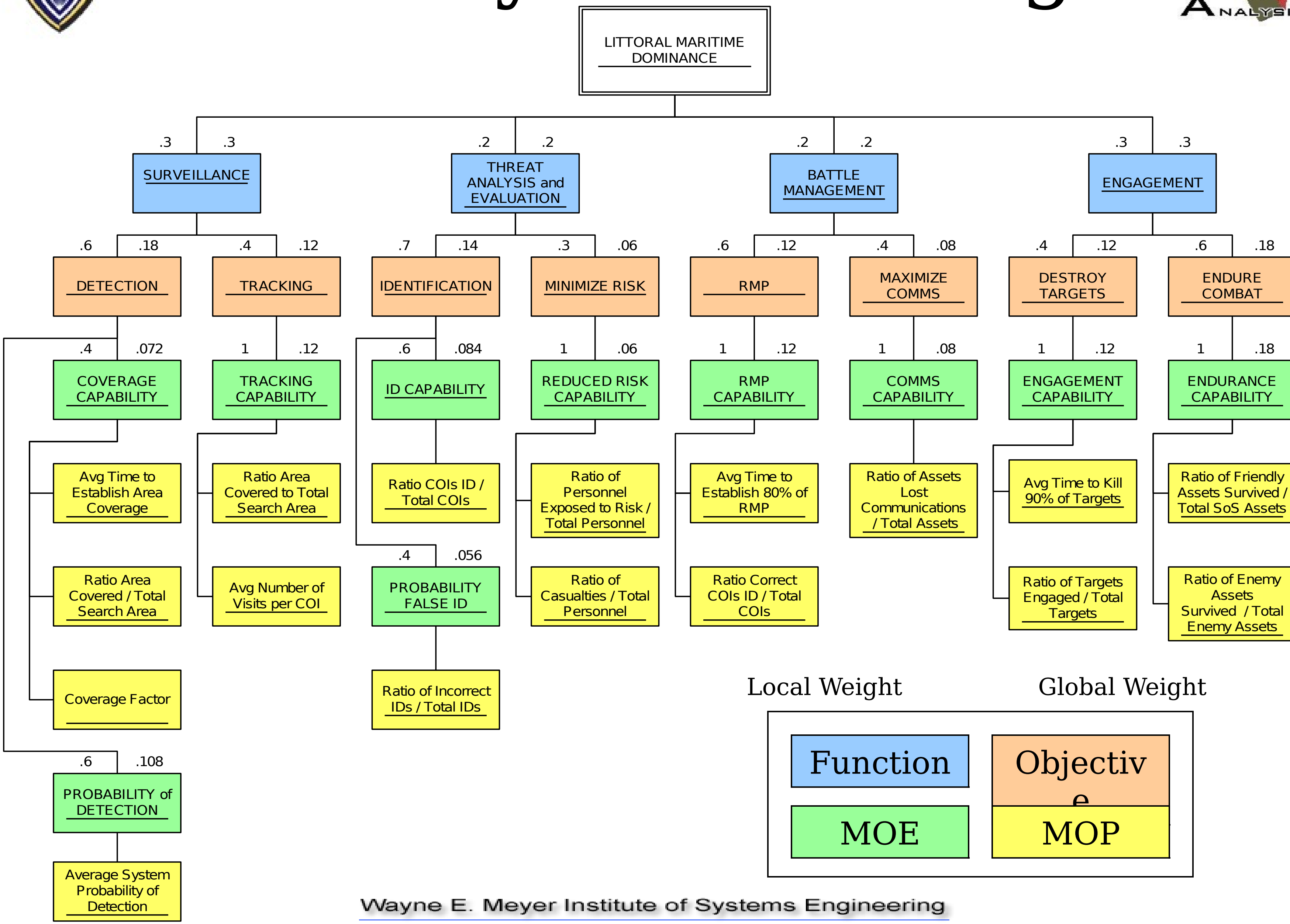
Effective Need

Develop a SoS Solution to Enable SEA BASING and SEA STRIKE by Providing Maritime Dominance in the Littoral Environment Through Cooperative Surveillance, Threat Analysis and Evaluation, Battle Management, and Engagement

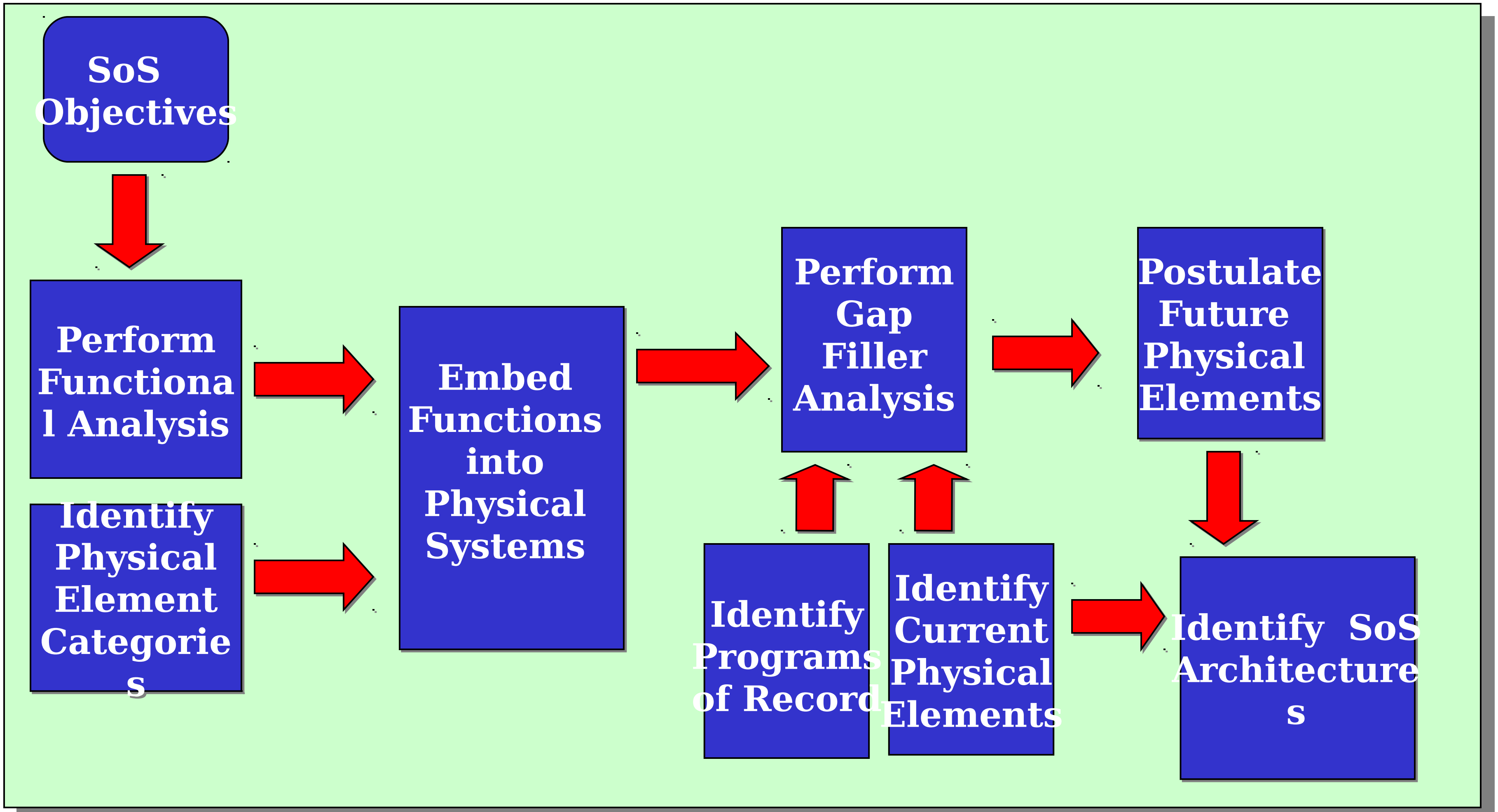
SoS Development Process

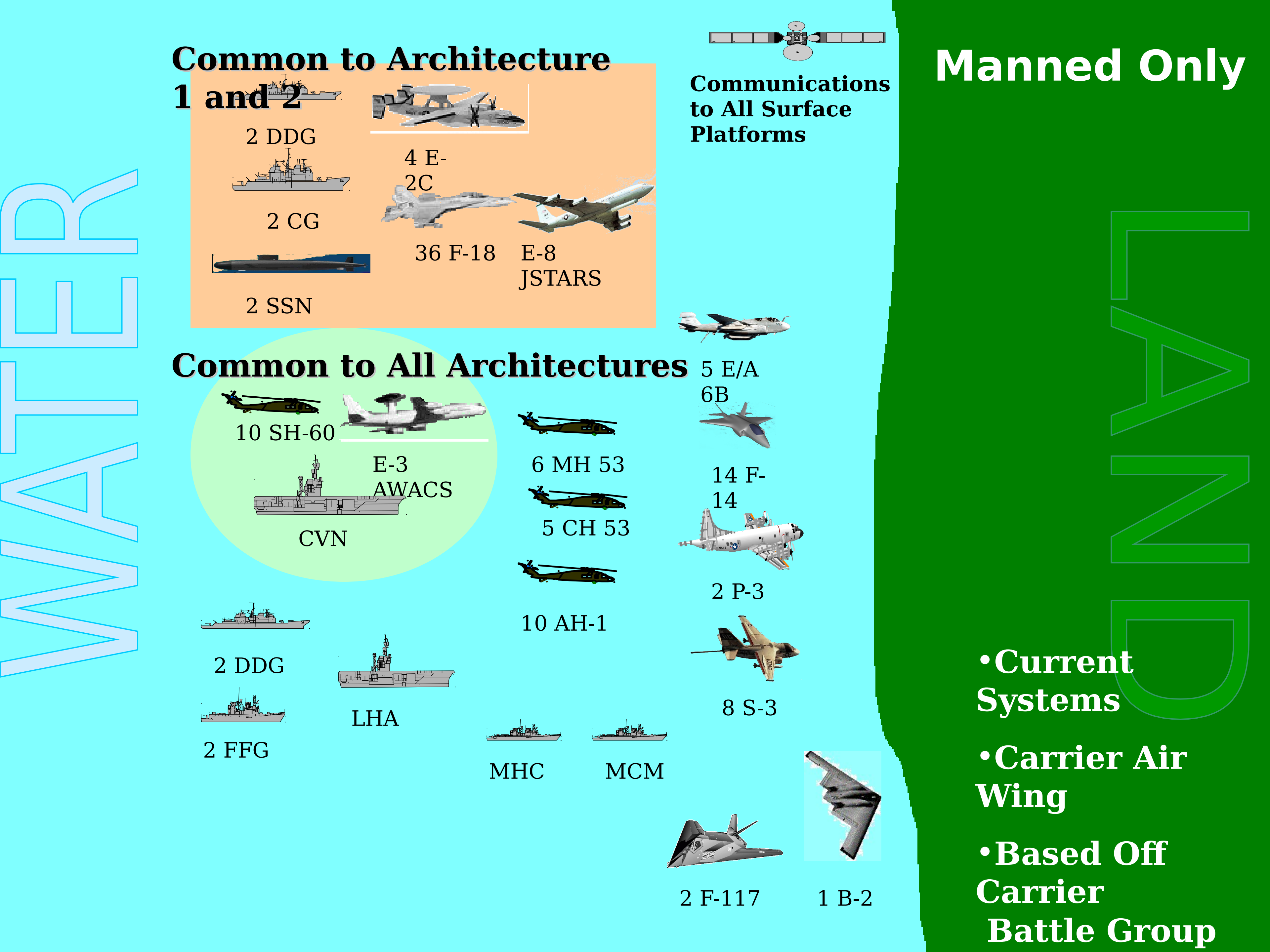


Value Systems Design

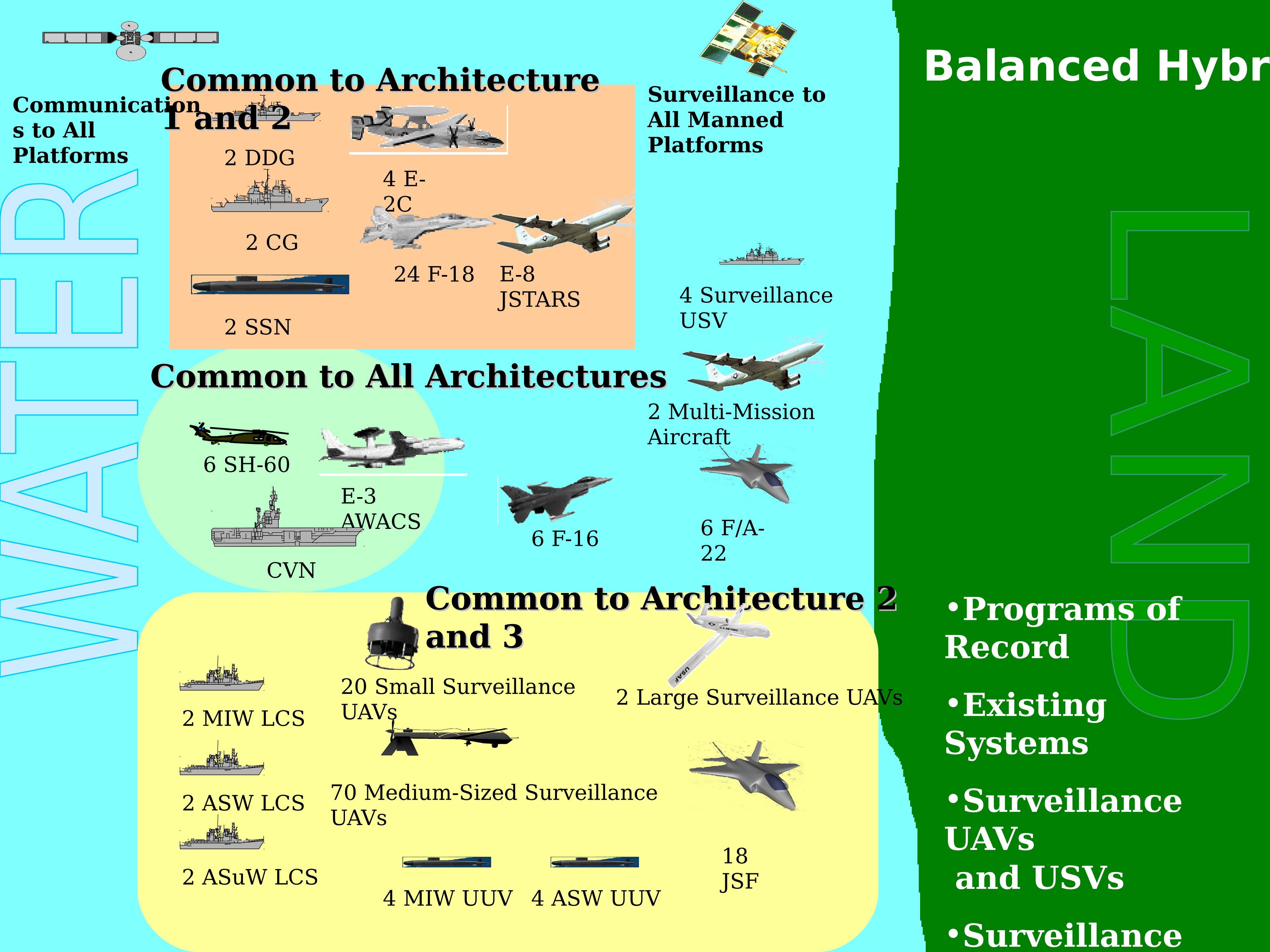


SoS Architectures Definition Process

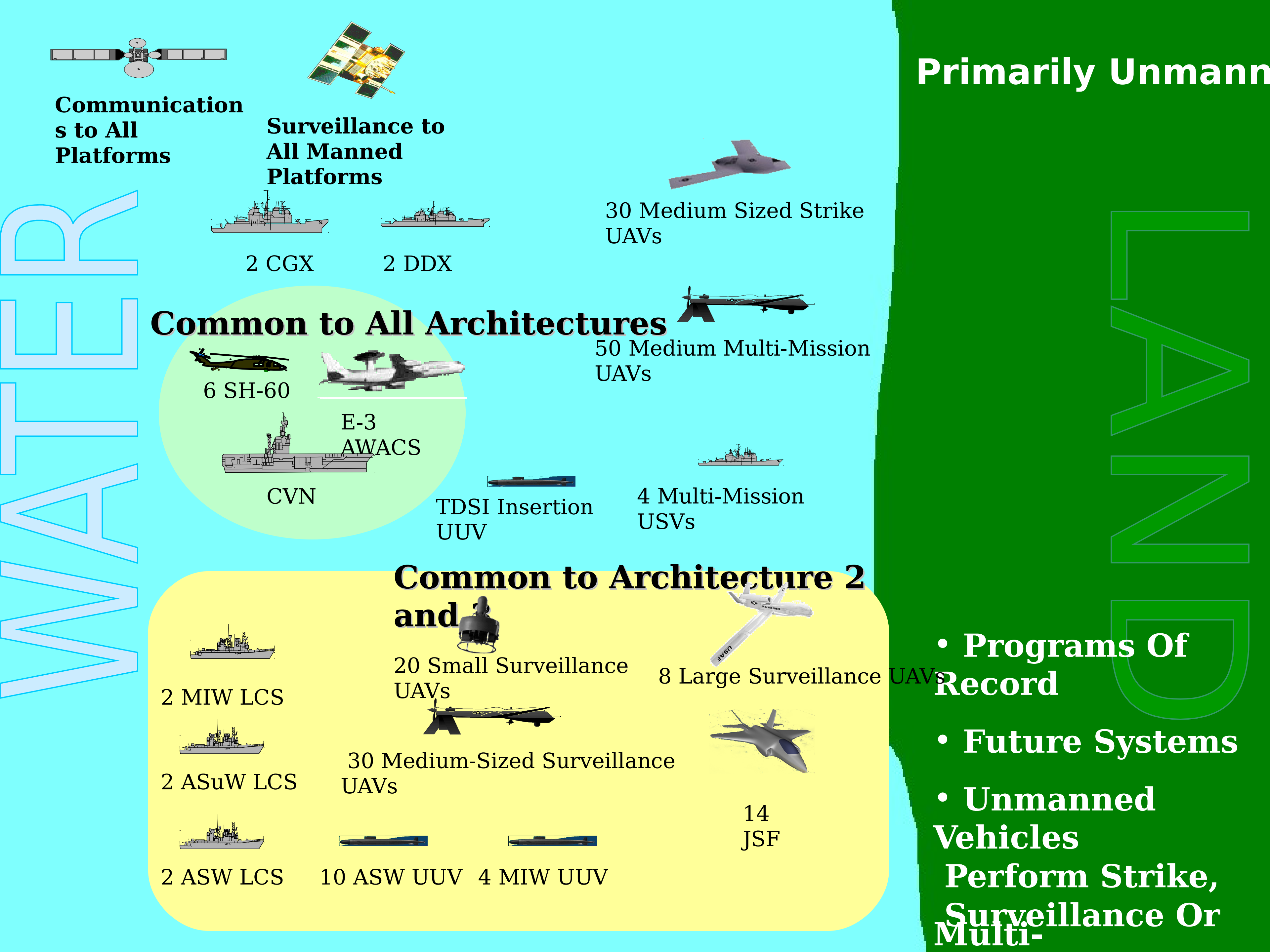




Common to Architecture 1 and 2
2 DDG
4 E-2C
2 CG
36 F-18
E-8 JSTARS
2 SSN
Communications to All Surface Platforms
Manned Only
WATER
LAND
Common to All Architectures
5 E/A 6B
10 SH-60
E-3 AWACS
6 MH 53
14 F-14
CVN
5 CH 53
2 P-3
10 AH-1
2 DDG
LHA
8 S-3
2 FFG
MHC
MCM
2 F-117
1 B-2
•Current Systems
•Carrier Air Wing
•Based Off Carrier Battle Group



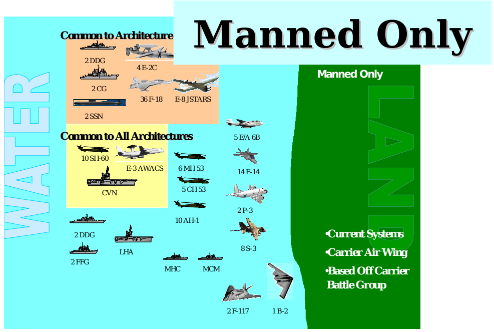
Balanced Hybr
Communications to All Platforms
Common to Architecture 1 and 2
2 DDG
4 E-2C
2 CG
24 F-18
E-8 JSTARS
2 SSN
Surveillance to All Manned Platforms
4 Surveillance USV
2 Multi-Mission Aircraft
Common to All Architectures
6 SH-60
E-3 AWACS
CVN
6 F-16
6 F/A-22
WATER
LAND
Common to Architecture 2 and 3
2 MIW LCS
20 Small Surveillance UAVs
2 Large Surveillance UAVs
2 ASW LCS
70 Medium-Sized Surveillance UAVs
2 ASuW LCS
4 MIW UUV
4 ASW UUV
18 JSF
•Programs of Record
•Existing Systems
•Surveillance UAVs and USVs
•Surveillance

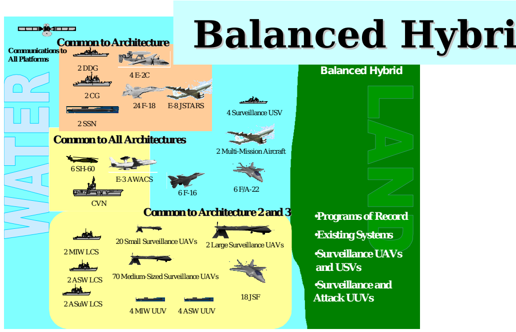


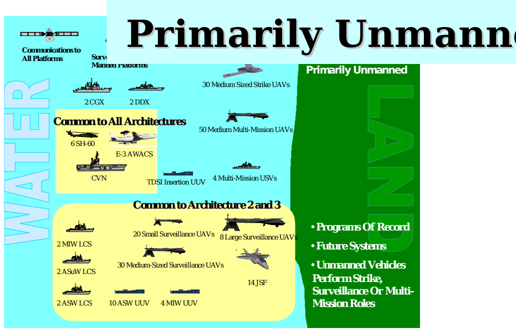
Primarily Unmann
Communications to All Platforms
Surveillance to All Manned Platforms
2 CGX
2 DDX
30 Medium Sized Strike UAVs
WATER
LAND
Common to All Architectures
50 Medium Multi-Mission UAVs
6 SH-60
E-3 AWACS
CVN
TDSI Insertion UUV
4 Multi-Mission USVs
Common to Architecture 2 and 3
20 Small Surveillance UAVs
8 Large Surveillance UAVs
2 MIW LCS
30 Medium-Sized Surveillance UAVs
2 ASuW LCS
14 JSF
2 ASW LCS
10 ASW UUV
4 MIW UUV
• Programs Of Record
• Future Systems
• Unmanned Vehicles Perform Strike, Surveillance Or Multi-

Architecture Summary

- Three Architectures With Progressing Reliance on UVs
  - Manned Only
  - Balanced Hybrid
  - Primarily Unmanned
- Architecture Effectiveness Modeled in Simulative Study Against Test Scenarios







South China Sea Scenario

- PRC Warship Strafed by Philippines Fighter
- PRC Naval Blockade of Puerta Princessa
  - Historical Rights and Economic Requirements
  - Need to Establish Safety Perimeter Around South China Sea
- PRC Reinforcement of Presence in the Spratly Islands
  - Paved Runways
  - Pier and Maintenance Facilities
  - ADA Batteries and Ballistic Missile Sites.
- PRC Invasion of Kepulauan Natuna (Indonesia)
- PRC Invasion of Palawan After a 30-day Blockade
  - Land, Air, Sea, and Missile Forces Moved to Island

Scenario Criteria

PRC Invasion Force

Aircraft 735

Surface 79

3 SOVREMMENY DDG
1 CV + 30 SU-30
55 DDG, FFG, & PGM

Subsurface 21

5 Type 091/093 SSN
15 Diesel SS (4 Kilo)

MARDIV 1

ARTDIV 1

INFDIV 7*

*3 Additional Reserve (Guangzhou)

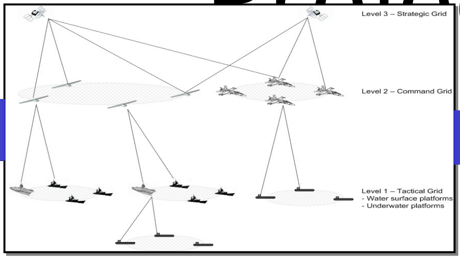
No Heavy Armor Division
Light Armor Units With MANPADS

- **Tactical Littoral Environments**
- **Scenario Definition Guided By Complexity**
  - Mission
  - Enemy Force Structure
  - Level of Hostility

Scenario	Enemy	Conflict	Escalation
Benign	Neutral	Unlikely	Unlikely
Nominal	Aggressive	Medium	Low
Stressing	Hostile	High	Medium

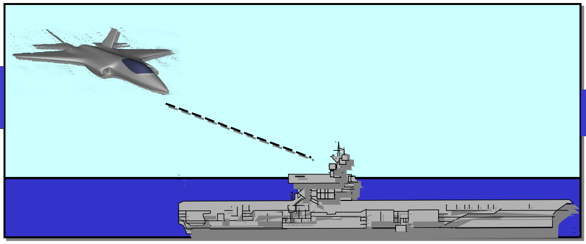
Campus Wide Integrated Project

COMMUNICATIONS
Conceptual Communications Network



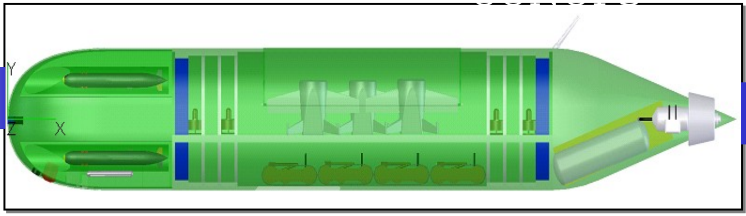
Extend™
Link Capacity 24 Mbps
Max. Comm. Range 60 km

INFORMATION ASSURANCE
Technology Exploitation Study and Limitation Parameters



Littoral Deployment CONOPS

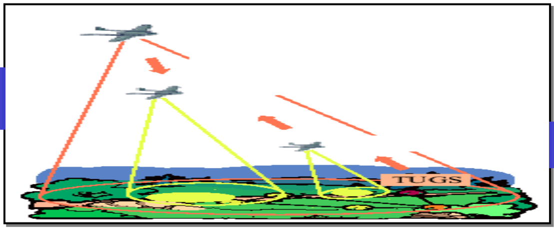
LAND SYSTEMS
Submersible UV Craft Carrier



Littoral Deployment CONOPS

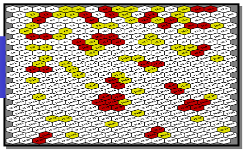
ALWSE-MC
- **5 Golden Eye UAVs**
- **20 iSTAR UAVs**
- **4 REMUS UUVs**
- **6 TALON Robot UGV**

SENSORS
In Depth Sensor Study for Operation in Littorals



Excel
- **Center Frequency 440 MHz**
- **BW 19.38 MHz**
- **Peak Power 1000 W**
- **Average Power 19 W**
- **Azimuth 3dB Beam Width 19°**
- **Elevation 3dB Beam Width 38°**
- **Nominal Gain 14 dB**

OR
Analytical Support Conceptual Modeling



Littoral Deployment CONOPS

Cost Estimation Results

Architecture	Cost in FY04$B Purchase Cost	O&S*	TOC**
Manned Only	0	1.53	23
Balanced Hybrid	4.7	1.34	24.3
Primarily Unmanned	10.4	1.13	25.8

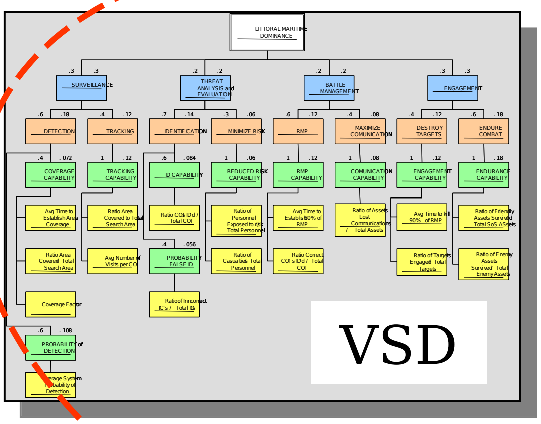
*** Per 1-year Basis**

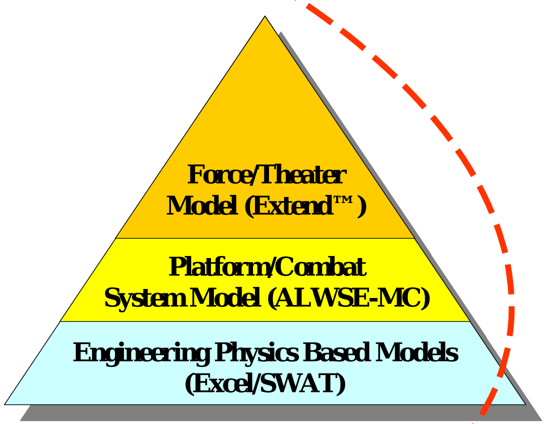
**** Per 10-year Basis Including Inflation**

Cost Estimation Methodology

- All O&S Costs in FY2003 From VAMOSC, AFTOC and OSMIS Databases
- Costs for Future Systems (i.e., UVs and (X) Ships) Estimated Using Analogy Technique
- Derivation of Proposed Future System Unit Cost Using Cost Factors
  - Complexity
  - Miniaturization
  - Productivity Improvement

Simulative Study Overview





Modeling Framework

Result

- Quantitative Data Provided to Answer Important Questions

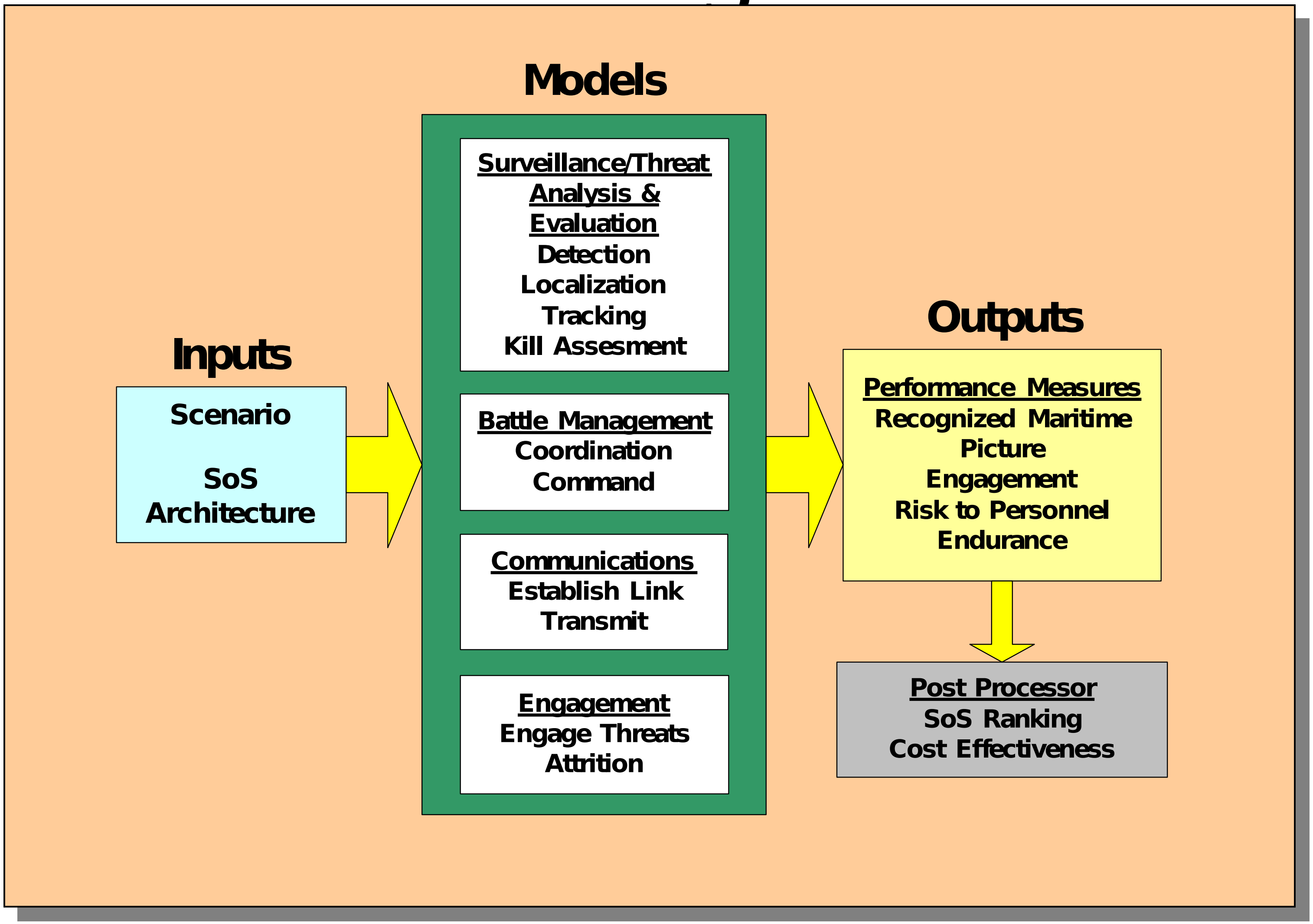
Method

- Important Questions and Sensitive Design Variables Identified
- Comprehensive Modeling Framework Developed to Answer the Important Questions

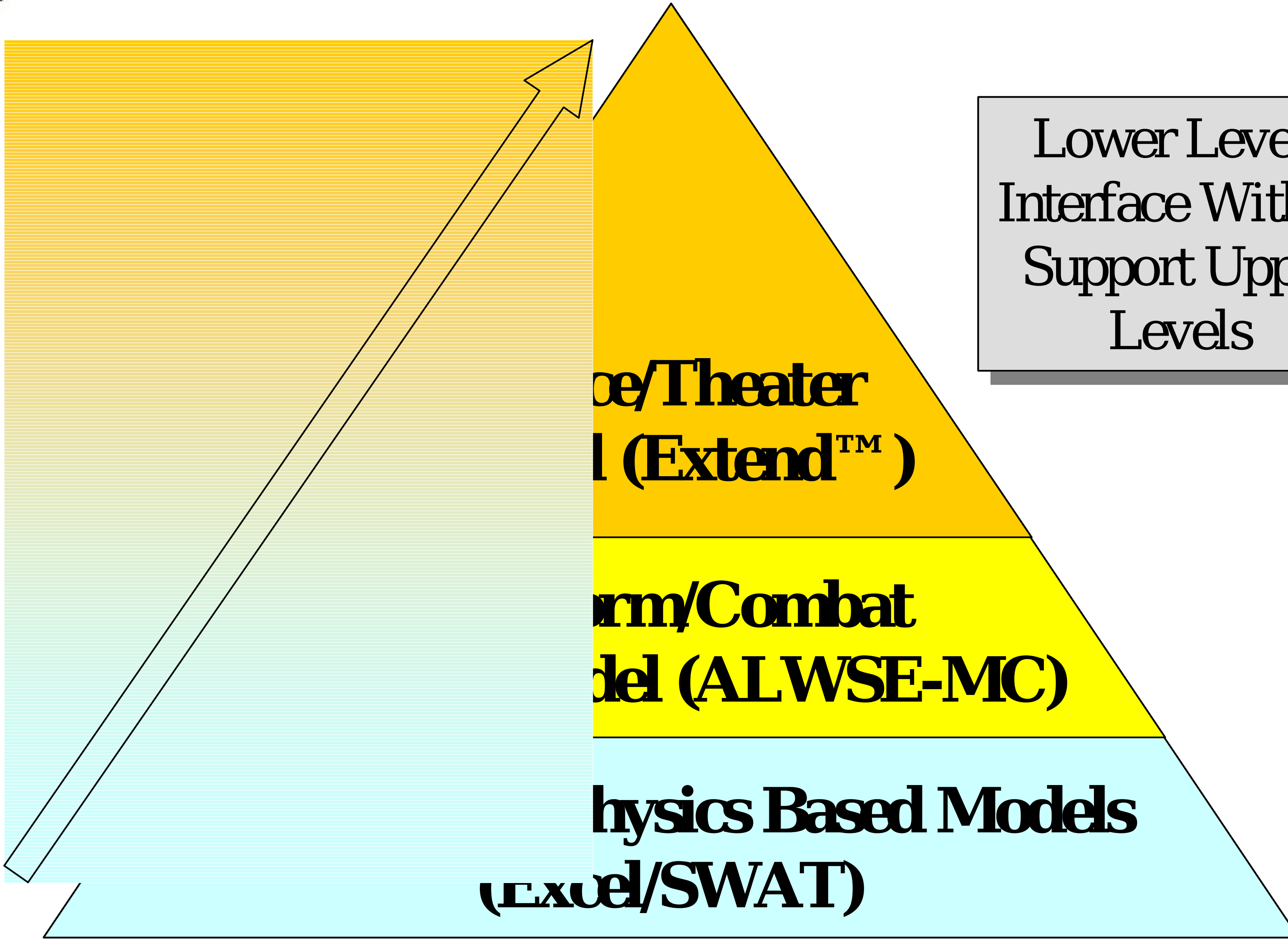
Run#	Config	SoS Arch (1,2,3)	CNA (1,2,3)	C2 (1,2)	PPD (1,2,3)	Scenario / Hostility (1,2,3)	Total COIs	COIs Detected	COIs Localized &	Enemy Targets Killed	Weapons Fired	Total Personnel	Personnel Exposed to Risk	Casualties	Total SoS Platforms	SoS Platforms Killed	Time to Max RMP Ratio (hrs)	Max RMP Ratio
1	1	1	1	1	1	1	5	5	5	3	5	9755	0	0	106	0	0.569	1
2	2	1	1	1	1	2	133	133	133	10	36	9755	129	455	106	3	28.905	1
3	3	1	1	1	1	3	858	858	858	47	137	9755	0	8393	106	9	[illegible]	1
4	4	1	1	1	2	1	5	5	5	4	5	9755	0	0	106	0	1.501	1
5	5	1	1	1	2	2	133	133	133	130	151	9755	493	646	106	2	28.533	1
6	6	1	1	1	2	3	858	858	858	14	78	9755	0	7377	106	6	32.267	1
7	7	1	1	1	3	1	5	5	5	3	4	9755	0	0	106	0	0.570	1
8	8	1	1	1	3	2	133	133	133	21	46	9755	323	728	106	2	28.599	1
9	9	1	1	1	3	3	858	858	858	279	469	9755	0	9283	106	40	30.588	1
10	10	1	1	2	1	1	5	5	5	4	4	9755	0	0	106	0	0.570	1
11	11	1	1	2	1	2	133	133	133	9	24	9755	2	129	106	1	28.090	1
12	12	1	1	2	1	3	858	858	858	226	398	9755	0	9296	106	50	38.714	1
13	13	1	1	2	2	1	5	5	5	4	4	9755	0	0	106	0	0.570	1
14	14	1	1	2	2	2	133	133	133	129	175	9755	544	1652	106	4	28.962	1
15	15	1	1	2	2	3	858	858	858	12	75	9755	0	2194	106	5	30.676	1
16	16	1	1	2	3	1	5	5	5	2	4	9755	0	0	106	0	1.157	1
17	17	1	1	2	3	2	133	133	133	109	136	9755	801	0	106	0	27.629	1
18	18	1	1	2	3	3	858	858	858	251	402	9755	0	9412	106	35	29.236	1
19	19	1	2	1	1	1	5	5	5	4	4	9755	0	0	106	0	0.570	1
20	20	1	2	1	1	2	133	133	133	19	48	9755	452	0	106	0	28.600	1
21	21	1	2	1	1	3	858	858	858	265	422	9755	0	9149	106	34	31.187	1
22	22	1	2	1	2	1	5	5	5	2	4	9755	0	0	106	0	0.570	1
23	23	1	2	1	2	2	133	133	133	27	53	9755	129	584	106	2	30.828	1
24	24	1	2	1	2	3	858	858	858	271	439	9755	0	9297	106	34	30.188	1
25	25	1	2	1	3	1	5	5	5	2	3	9755	0	0	106	0	0.618	1
26	26	1	2	1	3	2	133	133	133	30	58	9755	324	364	106	1	29.249	1
27	27	1	2	1	3	3	858	858	858	281	443	9755	0	9184	106	29	29.638	1
28	28	1	2	2	1	1	5	5	5	4	4	9755	0	0	106	0	0.981	1
29	29	1	2	2	1	2	133	133	133	26	52	9755	354	326	106	3	28.524	1
30	30	1	2	2	1	3	858	858	858	303	491	9755	0	9421	106	37	29.734	1
31	31	1	2	2	2	1	5	5	5	3	4	9755	0	0	106	0	0.972	1
32	32	1	2	2	2	2	133	133	133	126	167	9755	7471	220	106	1	29.250	1
33	33	1	2	2	2	3	858	858										
34	34	1	2	2	3	1	5	5										
35	35	1	2	2	3	2	133	133										
36	36	1	2	2	3	3	858	858										
37	37	1	3	1	1	1	5	5										
38	38	1	3	1	1	2	133	133										
39	39	1	3	1	1	3	858	858										
40	40	1	3	1	2	1	5	5										
41	41	1	3	1	2	2	133	133										
42	42	1	3	1	2	3	858	858										
43	43	1	3	1	3	1	5	5										
44	44	1	3	1	3	2	133	133										
45	45	1	3	1	3	3	858	858										
46	46	1	3	2	1	1	5	5										
47	47	1	3	2	1	2	133	133										
48	48	1	3	2	1	3	858	858										
49	49	1	3	2	2	1	5	5										

Simulation Output Table

Simulative Study Design



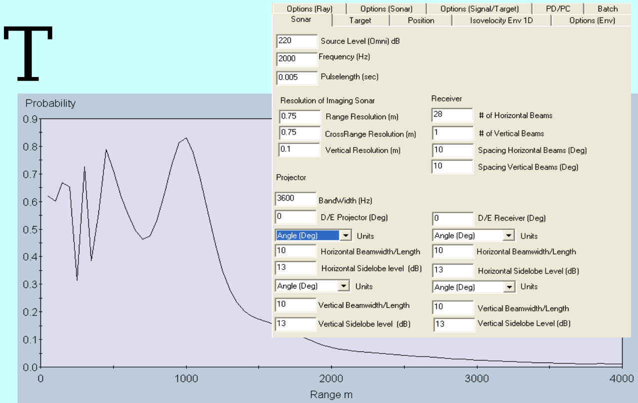
Modeling Framework



Lower Levels Interface With & Support Upper Levels

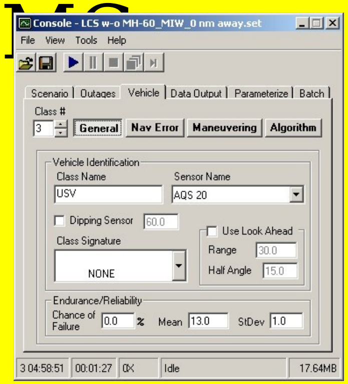
Modeling Tools Interface

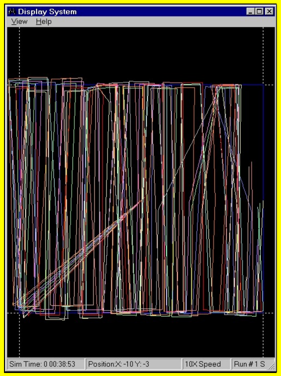
Excel/SWAT



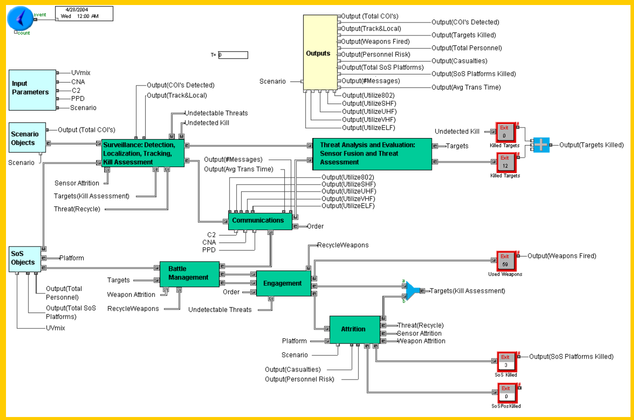
Lateral Range Detection Curves

ALWSE-MC





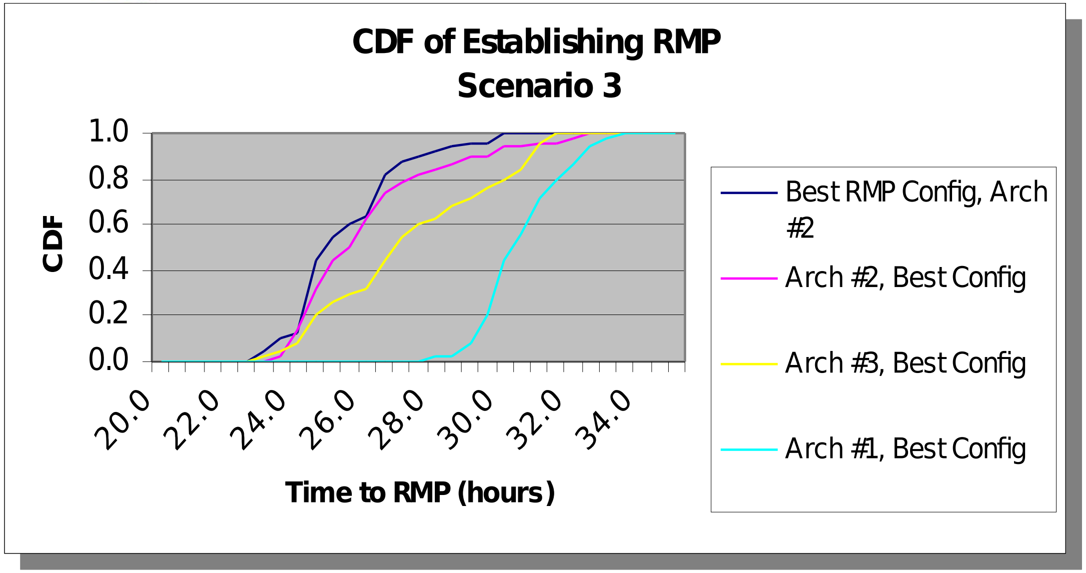
Extend™

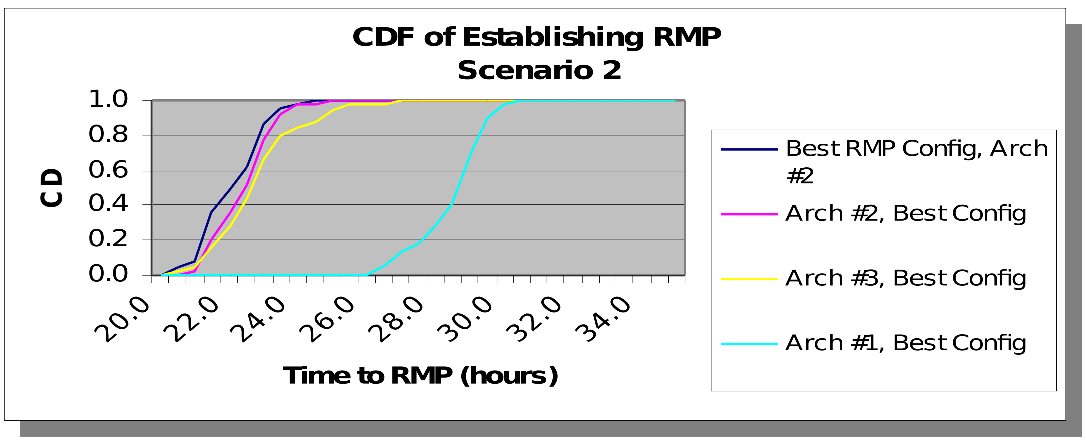


Database Tables

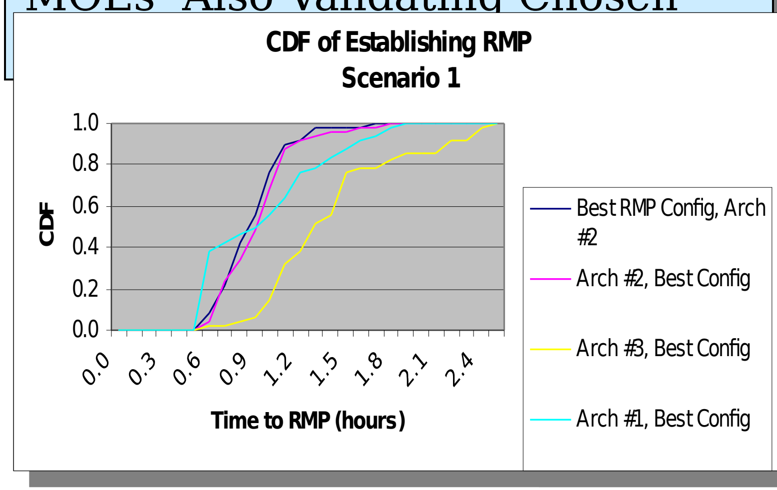
Time To Detection Data

Selected Configuration Validation





- Comparison of CDF for Time-to-RMP for Best Configuration from 162 Configurations to CDFs for Selected Configurations
- Excellent Agreement between Best-Configuration CDF and CDF for Selected Architecture 2-Best Configuration Thus Validating Chosen Configuration
- Comparison of CDFs for Other MOEs Also Validating Chosen



CDF: Cumulative Distribution Function

Arch 1 – Manned Only
Arch 2 – Balanced Hybrid
Arch 3 – Primarily Unmanned

Effects of Configuration Attributes On RMP

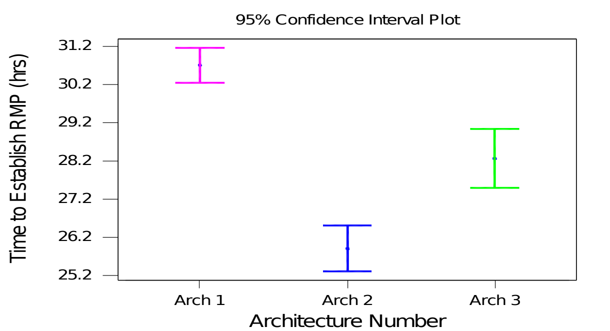
Arch 1 – Manned Only

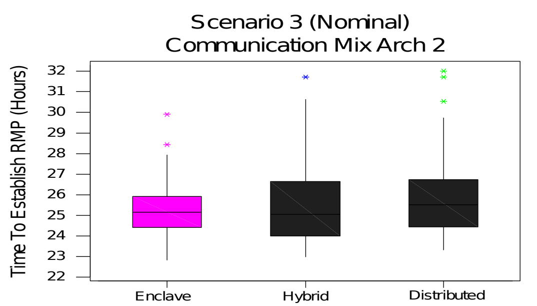
Arch 2 – Balanced Hybrid

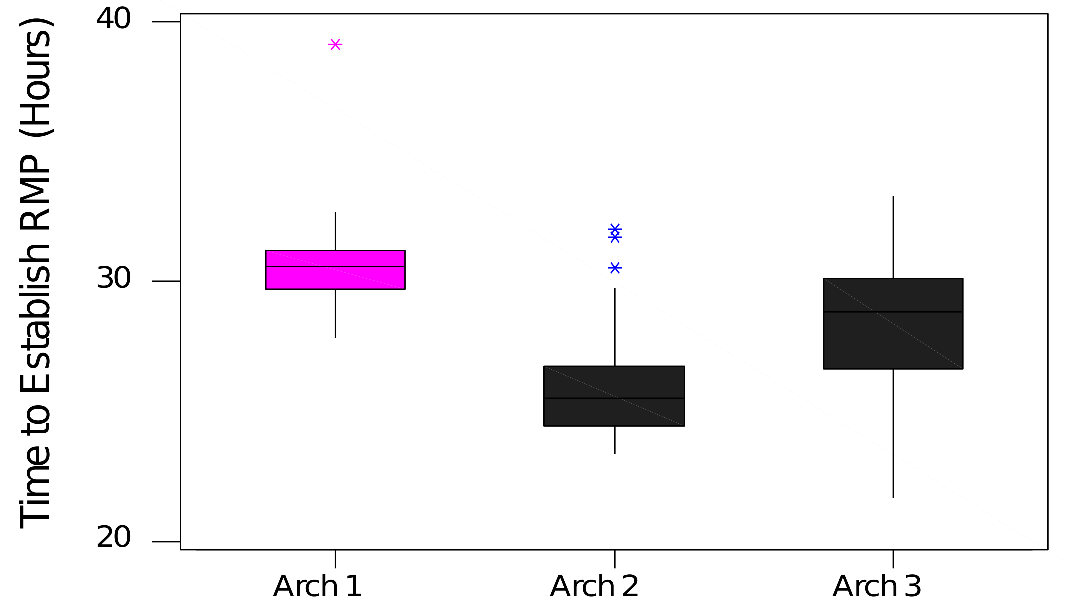
Arch 3 – Primarily Unmanned

- Significant Effects of Unmanned/Manned Ratio on Time-to-RMP
- Insignificant Effects of Command and Control Structure &

etwork Architecture



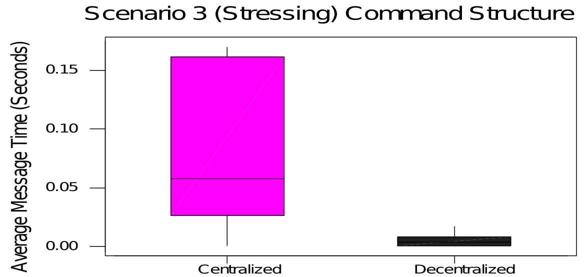


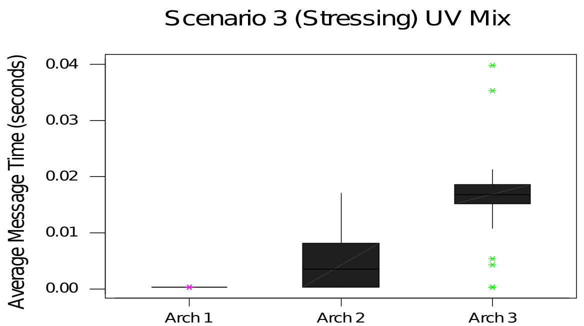


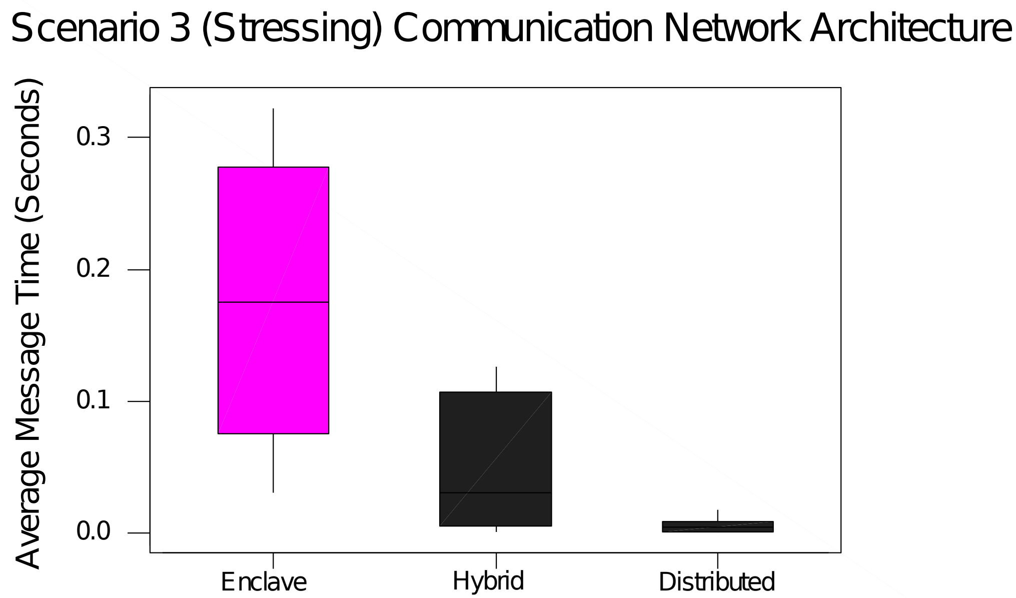
Effects of Configuration Attributes On Communications Performance

Arch 1 – Manned Only
Arch 2 – Balanced Hybrid
Arch 3 – Primarily Unmanned

- Significant Effects of Unmanned/Manned Ratio, Command & Control and Communication Network Architecture on Communication Performance (Message Delay)

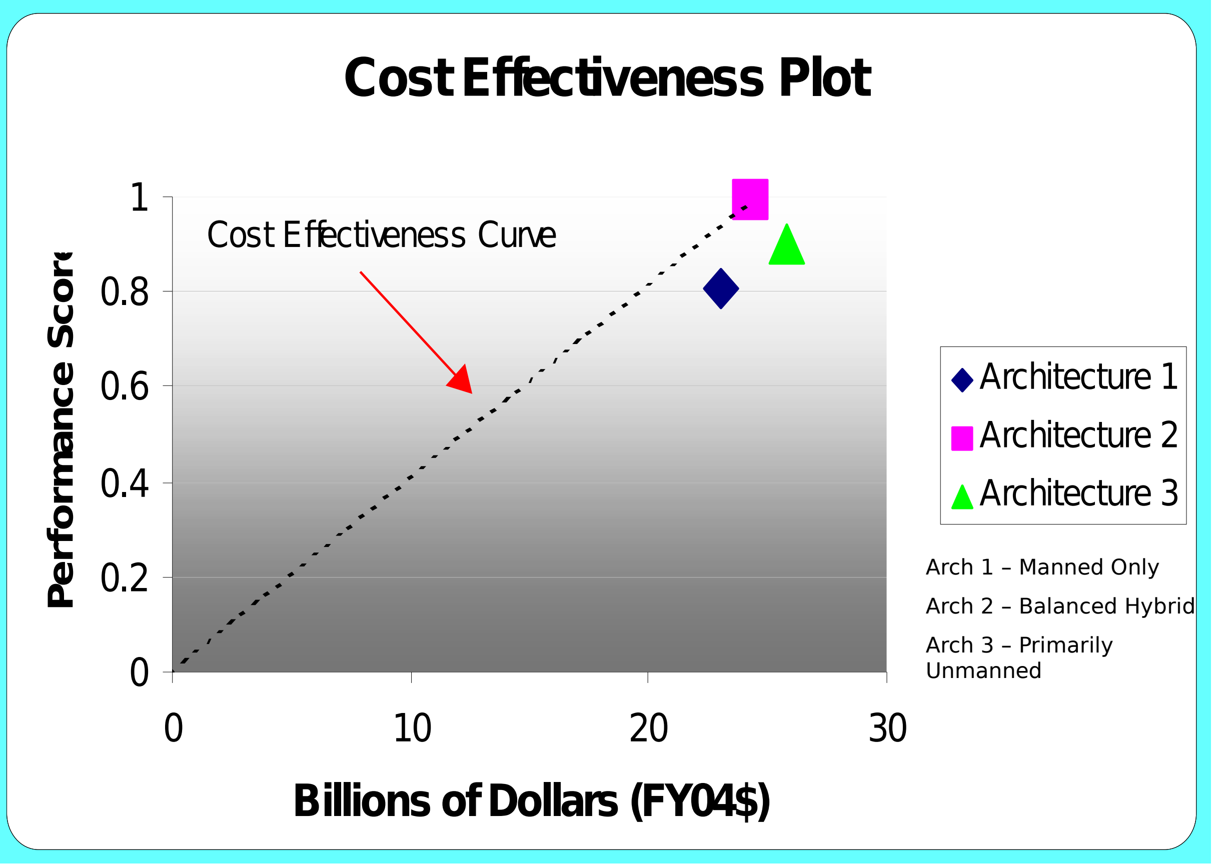






Cost Effectiveness Curve
for Architecture Recommendation

- Balanced Hybrid Cost Effective & Cost Efficient
- Manned Only Cost Effective Not Cost Efficient
- Primarily Unmanned Dominated (Neither Effective or Efficient)



Balanced Hybrid Recommended Based on Cost & Performance

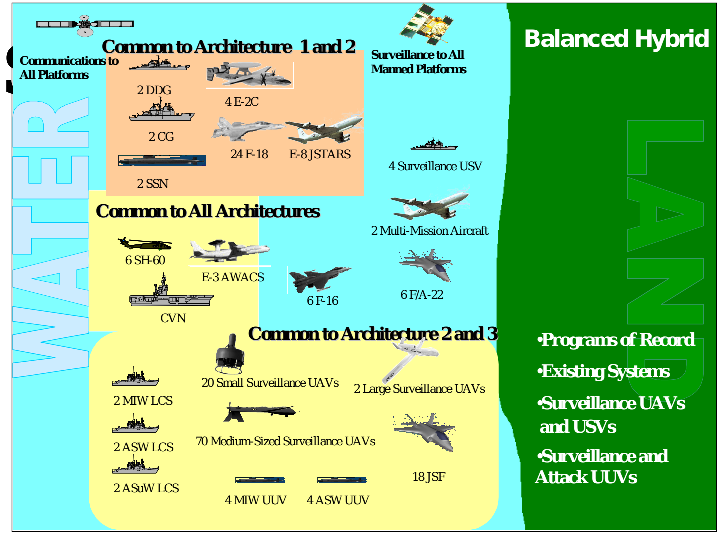
for Maritime Dominance in

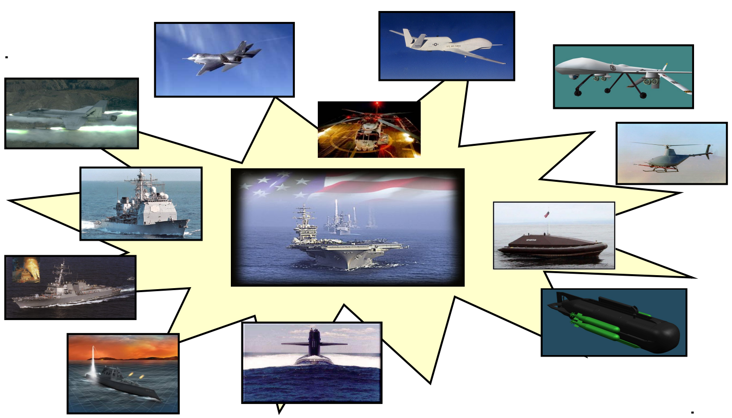
rals

•**Unmanned Vehicles Complement But Cannot Replace Manned Platforms**

•**Recommended System of Systems Enabling SEA BASING and SEA STRIKE in 200 nm by 200 nm Littoral Operation Area in 2020 Timeframe**

- **Consists of Unmanned/Manned Vehicle Ratio of Approximately 1.5 to 1**
- **Utilizes Distributed Communications with 100nm Physical Platform Distribution**
- **Employs Decentralized Command & Control Structure**
- **Is Cost Effective Relative to Other Alternatives**





- **Distributed Communications**
  - Faster Dissemination of Information
  - Minimum Impact on Throughput with Node Failures
- **Decentralized Command and Control**
  - Shorter Reaction Times
  - Less Network Demand
  - Single C2 Node Failure Avoidance
- **100 nm Platform Distribution**
  - Superior Overall Performance